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## HELMET WITH BUILT-IN SPEAKER SYSTEM AND SPEAKER SYSTEM FOR HELMET

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to a helmet with a built-in speaker system and a speaker system for a helmet, and more particularly relates to a helmet with piezoelectric film speakers, and piezoelectric film speakers for a helmet.

#### 2. Description of the Background Art

Magnetic speaker systems including a voice coil mounted on a cone have been widely used in helmets up to this time. However, such speaker systems are difficult to downsize or make light in weight. There has been a great demand for improved speaker systems for helmets. In order to attach a speaker system in the confined space of a helmet and make a user feel comfortable, the use of the piezoelectric film speakers has been proposed in Japanese Patent Laid-Open No. Sho 63-175106 and Japanese Utility Model Laid-Open No. Sho 63-44584.

The piezoelectric film expands and contracts in response to voltages applied to an electrode. Therefore, when applying the piezoelectric film to a speaker, it is necessary to convert expansion and contraction of the surface of the piezoelectric film into oscillations of the film surface. This requirement is satisfied by maintaining the piezoelectric film in a curved state, which enables the piezoelectric film to function as a speaker.

In such a case, output performance in response to input signals, i.e. sound pressure level and frequency characteristics of the piezoelectric film as a speaker, depends upon the relative relationship between the expansion-contraction, and the oscillation. This relative relationship depends upon the degree to which the piezoelectric film is curved, i.e. a radius of curvature of the curved portion of the piezoelectric film. Further, there is a limitation to the radius of curvature in order for which the piezoelectric film to perform in the required manner. If such a limitation is not observed and is exceeded,

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the piezoelectric film speaker cannot produce a sufficient sound pressure level or may have deteriorating frequency characteristics, so that the speaker cannot demonstrate the desired capacity and sound quality.

5 In the foregoing related art, no definite measures seem to have been taken in order to strictly keep the piezoelectric film curved in the predetermined range. Therefore, existing piezoelectric film speakers do not function satisfactorily.

#### SUMMARY OF THE INVENTION

10 The present invention is intended to overcome the foregoing problems of the related art and to provide piezoelectric film speakers for a speaker system to be used in a helmet. The present invention is also intended to provide a helmet including such piezoelectric film speakers which can function satisfactorily.

15 In order to accomplish the foregoing object, the present invention features the following:

(1) a speaker system is attached on an inner surface of a helmet and comprises a pair of piezoelectric film speakers which function as main surfaces, oscillate in response to an input signal and have their peripheral edges supported by frames;

20 (2) the frames support the piezoelectric film speakers in a curved state; and

(3) the speaker system is attached on the inner surface of a helmet shell.

25 According to the first feature, the peripheral edge of each piezoelectric film speaker is held by the frame, which enables the piezoelectric film speaker to maintain its desired shape and posture without adversely affecting oscillation characteristics of the main surface thereof.

30 In the second feature, each frame is designed in accordance with a desired shape of the piezoelectric film speaker (i.e. a three-dimensional shape or a curved state of the piezoelectric film speaker), which allows the piezoelectric film speaker to be fixedly attached in the desired curved state

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without adversely affecting the oscillation characteristics of the main surface.

With the third feature, the speaker system is not attached to an interior member such as an elastic liner which is easily aged but is attached  
5 to the hard helmet shell which is substantially free from aging. Therefore, the speaker system is reliably attached to the helmet in the desired posture.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while  
10 indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15 The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus, are not limitive of the present invention, and wherein:

20 Fig. 1 is a sectional view of the helmet including the speaker system according to a first embodiment of the invention;

Fig. 2 is a side view of the helmet of Fig. 1;

Fig. 3 is an assembly drawing of the piezoelectric film speaker of the first embodiment;

Fig. 4 is a front view of the piezoelectric film speaker;

25 Fig. 5 is a sectional view of the piezoelectric film speaker taken along line 5-5 of Fig. 4;

Fig. 6 is a sectional view of the piezoelectric film speaker taken along line 6-6 in Fig. 4.

30 Fig. 7 is an assembly drawing of the piezoelectric film speaker according to a second embodiment;

Fig. 8 is a sectional view of the piezoelectric film speaker of the second embodiment;

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Fig. 8 is a side view of the piezoelectric film speaker;

Fig. 9 is a side view of the piezoelectric film speaker in the second embodiment;

Fig. 10 is a sectional view of the piezoelectric speaker in a modified example of the second embodiment;

Fig. 11 is a sectional view of the helmet with the built-in speaker system in the second embodiment; and

Fig. 12 is a sectional view of the piezoelectric film speaker in a further modified example of the second embodiment.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention will be described with reference to preferred embodiments shown on the accompanying drawings. The helmet 1 includes a thin hard helmet shell 11 made of a fiber-reinforced plastic material, for example. A head liner 121A is attached on an inner surface of the helmet shell 11 and made of foamed styrene. A head inner part 12A is detachably attached to the head liner 121A using a hook-and-loop fastener such as VELCRO or the like. An ear inner part 12B and a chin inner part 12C are detachably attached together with a liner 121 to the inner surface of the helmet shell 11. A chin strap 13 is connected to the helmet shell 11.

Referring to Fig. 2, the ear inner part 12B (including the liner 121) is in the shape of a letter U or in the shape of a ring in order to maintain a predetermined space around the ears to prevent the ears from being pressed and protecting the sides of a user's head against the helmet. Further, the head liner 121A and head the inner part 12A thereof are shaped such that they do not come into contact with the user's ears.

A speaker system 10 includes a pair of left and right speakers 10L and 10R which are detachably attached to the inner surface of the helmet shell 11 in a space 14 defined by the foregoing liners, using a fastener such as the hook-and-loop fastener VELCRO. According to the invention, the speaker system 10 is directly attached to the hard helmet shell 11 which is substantially free from aging, rather than the elastic liner 121 (or the head

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inner part 12A) which tends to age extensively. Therefore, the speaker system 10 can be reliably attached in the predetermined posture.

The speaker system 10 includes a pair of piezoelectric film speakers 201 made of polyvinylidene fluoride (PVDF) or the like, frames 202 for supporting the piezoelectric film speakers 201 around their peripheral edges, and laminated films <sup>made of</sup> 203 for protecting the piezoelectric film speakers 201, all of which are laid over one after another as shown in Fig. 5. Hook-and-loop fasteners 204 such as VELCRO are stuck along opposite side edges of the laminated films 203 in order to attach the speaker system 10 onto the inner surface of the helmet shell 11 in the spaces 14 defined by the liner 121. Electrode wiring 205 is connected to each piezoelectric film speaker 201.

Each of the frames 202 is made by shaping a moisture-proof and shock-resistant material such as nylon, polyethylene or polypropylene, or thick paper with a moisture-proof coating. In the invention, the piezoelectric film speaker 201 has its peripheral edge fixedly supported by the frame 202, and can be reliably and firmly maintained in the desired posture. Therefore, it is possible to provide the speaker system 10 with the desired performance.

Further, the frame 202 has its longer sides curved with a radius of curvature of approximately 210mm to 360mm in order to curve the piezoelectric film speaker 201 with the predetermined radius of curvature (of approximately 210mm to 360mm), as shown in Fig. 6 in an exaggerated state. The shorter sides of the frame 202 (shown in Fig. 5) may be flat or be slightly curved with the a radius of curvature of approximately 500mm.

According to the invention, the frames 202 are curved as described above, so that the piezoelectric film speakers 201 can be reliably maintained in the curved state without adversely affecting the oscillation thereof. This enables the piezoelectric film speakers 201 to output sound and voice-audio with excellent quality and sufficient pressure. The speaker system 10 is detachably attached to the helmet 1 using the hook-and-loop fasteners 204, so that it can be used with a desired helmet if the user has a plurality of helmets, or can be easily attached to a new helmet.

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Fig. 7 is an assembly drawing of a second embodiment of the speaker system which comprises a pair of piezoelectric film speakers 201, and frames 22 for supporting the piezoelectric film speakers 201 along their peripheral edges. The speaker system 10 is detachably attached to the inner surface of the speaker shell 11 using the hook-and-loop fastener (Velcro - not shown) as in the first embodiment.

Each frame 22 includes a pair of a frame piece 22a (at the shell side) and a frame piece 22b (at the ear side) which are joined with to each other. The piezoelectric film speaker 201 has its peripheral edge sandwiched between and held by the frame pieces 22a and 22b with some play therebetween.

The frame piece 22a includes a body 221 having a center window 220, four claws 222 provided at the centers of four sides of the body 221, a thin film-receiving portion 223 formed along the inner edge of the body 221, and a run-off portion 224 located on the body 221 in order to receive a lead wire 205.

The frame piece 22b includes a body 226 having a center window 225, four recesses 227 provided at the centers of four sides of the body 225 for engagement with the four claws 222, and a thin film-receiving portion 228 (see Fig. 8) formed along the inner edge of the body 226.

The speaker system 10 is assembled as follows: the piezoelectric film speaker 201 is placed in the film-receiving portion 223 of the frame piece 22a, the lead wire 205 is made to pass through the run-off portion 224, the frame piece 22b is engaged with the frame piece 22a, and the four claws 222 on the frame piece 22a are engaged with the four recesses 227 on the frame piece 22b.

Although not clearly shown in Figs. 7 and 8, the frame 22 (composed of the frame pieces 22a and 22b) is curved at least in one of two directions which are orthogonal with each other. Therefore, the piezoelectric film speaker 201 supported by the frame 22 is also curved with the radius of curvature substantially identical to that of the frame 22 (ideally the radius of curvature being 210mm to 360mm). In other words, the frame 22 is curved

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in accordance with the desired curved state of the piezoelectric film speaker 201.

Alternatively, the piezoelectric film speaker 201 may be curved as shown in Fig. 10. In this case, the frame 22 is flat, but the film-receiving portion 223 has a varying depth so that the piezoelectric film speaker 201 may be supported in a curved state.

The second embodiment is advantageous in the following respects in addition to the advantages of the first embodiment. Each piezoelectric film speaker 201 is sandwiched between and held by a pair of frame pieces 22a and 22b which are joined to each other. This structure enables easy and efficient assembling of the speaker system 10. Further, the user can replace a broken piezoelectric film speaker 201 with a new one without any problem.

Further, even when the frame 22 is not applicable to a helmet on hand because of the size or shape thereof, the piezoelectric speaker 201 can be used commonly for a plurality of helmets simply by obtaining a compatible frame 22.

In the foregoing embodiments, the speaker system 10 is assumed to be directly attached to the inner surface of the helmet shell 11. Alternatively, the speaker system 10 may be positioned near the user's ears regardless of a size or shape of a helmet, when the speaker system 10 is attached using spacers 131 having an appropriate thickness, as shown in Fig. 11. In such a case, the user may enjoy an increased sound pressure level, compared with when the speaker system 10 is directly attached to the helmet shell.

In place of raising the position of the speaker system 10 using the spacer 131, the frame piece 22a may be thickened, which is as effective as in the case of using the spacers 131. In other words, if a plurality of frame pieces 22a which are different in thickness are prepared, then an optimum frame piece 22a may be selected depending upon the size or shape of the helmet, and be used together with the frame piece 22b.

The invention can assure the following advantages:

(1) the piezoelectric film speakers can be reliably and firmly maintained in the desired shape and posture, so that the speaker system can assure excellent performances;

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(2) the piezoelectric film speakers can be reliably maintained in the curved state, so that the speaker system can output sound with sufficient quality and pressure;

(3) each of the piezoelectric film speakers is sandwiched between and  
5 held by a pair of the frame pieces, which facilitates assembling of the speaker system, and improves productivity;

(4) this structure enables the user to easily replace a broken piezoelectric film speaker with a new one;

(5) even if the frame cannot be applied to helmets with different sizes  
10 and shapes, the user can attach the speaker system to his or her helmet on hand simply by obtaining a compatible frame, and therefore the piezoelectric film speaker is applicable to a plurality of helmets;

(6) the speaker system is attached to the helmet shell made of a hard material which is free from aging rather than to a liner or an interior member  
15 made of an elastic material which tends to age extensively, and therefore the speaker system can be reliably and firmly maintained in the predetermined posture; and

(7) the speaker system is attached to the helmet using a detachable fastener such as VELCRO or the like, and can be easily attached to any  
20 helmet if the user has a plurality of helmets or when the user uses a new helmet.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such  
25 modifications as would be obvious to one skilled in the art are to be included within the scope of the following claims.